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Heterogeneous deep source versus shallow crustal imprints in the petrogenesis of kamafugites from San Venanzo volcano, Italy

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Within the wide compositional spectrum of potassium-rich magmatism in Central Italy, kamafugitic rocks in the Intra-Apennine Volcanic Province constitute the most alkalic and silica-undersaturated end-member, showing the highest enrichment in many incompatible trace elements. A close association with carbonatitic rocks has posed questions concerning the ambiguous origin of carbon, which may have been derived from the mantle source or from interaction with Mesozoic carbonates residing in the crust. We explored the crystallisation history of olivines and their melt inclusions (MI), separated from a representative rock specimen from San Venanzo, which enabled us to (1) determine the primary composition(s) of mantle-derived kamafugite melts and (2) trace the effects of crustal interaction on melt composition and magma evolution. Complex textures of olivine phenocrysts and their trace element compositions provide a framework for the sequence in which melt evolved within a single magmatic plumbing system.

Olivine crystals in the studied kamafugite show complex textures between core and rim parts. There are strong indications of drastic late-stage changes in the crystallisation regime, including irregular and patchy compositional zoning and increasing amounts of inclusions in the rims, as well as rare primary melt inclusions in pristine parts of the olivines (Fig. 1).

Pristine core parts, characterised by high Fo (93–90 mol%), low CaO (0.2–0.3 wt%) and Cr-spinel inclusions (Cr# ~0.7), are considered to have crystallised from a primary, mantle-derived melt. Compositions of homogenised melt inclusions in these core parts are consistent with derivation from high-MgO melts, but span a continuous range for K_2O, Na_2O, P_2O_5, TiO_2 and CaO content.

Contrastingly, the rim parts show a strong compositional gradient of decreasing forsterite (down to Fo_{70}) and increasing CaO (up to 1.8 wt%). Profiles of phosphorous contents in the olivines point to steep increases in the rim parts, indicating that they originated as rapid overgrowths onto phenocryst cores.

Homogenised MI from the rim parts are compositionally close to evolved carbonate-bearing volcanic products, natural skarns and glasses generated in carbonate assimilation experiments. These combined signatures suggest that the rim parts crystallised from an evolved melt that was contaminated through interaction with carbonate-rich lithologies. Fluid inclusions in the rim parts indicate that this interaction occurred at relatively shallow crustal levels (2–10 km; Fig. 1).

From the major and trace element content of core-hosted MI we infer that the kamafugite represents an assembly of primary melts with different compositions, controlled by low-degree melt extraction from a mantle source with mineralogical variations. Both the major and trace element content of core-trapped MI furthermore demonstrate an important role for apatite in the mantle source during primary melt generation of the San Venanzo kamafugites. Our observations are consistent with a mantle source affected by siliceous K_2O-rich and carbonate/apatite-rich metasomatic agents derived from subducted carbonate-bearing metapelites.

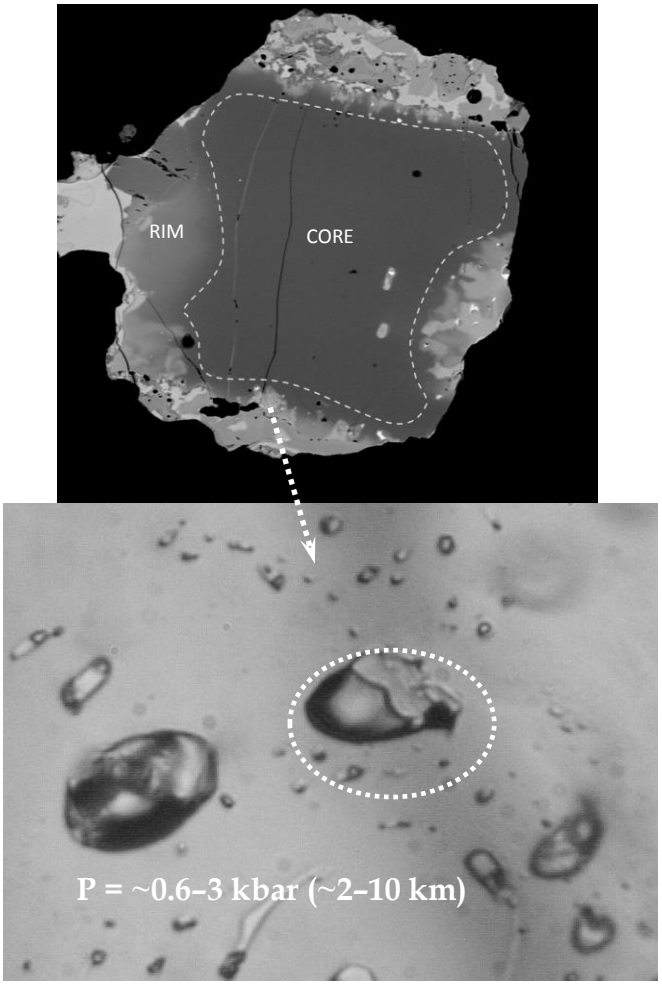

Fig. 1. *Typical texture of the studied olivines and fluid inclusions in the rim parts.*